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Developing inquiry competencies in science education by using rubrics

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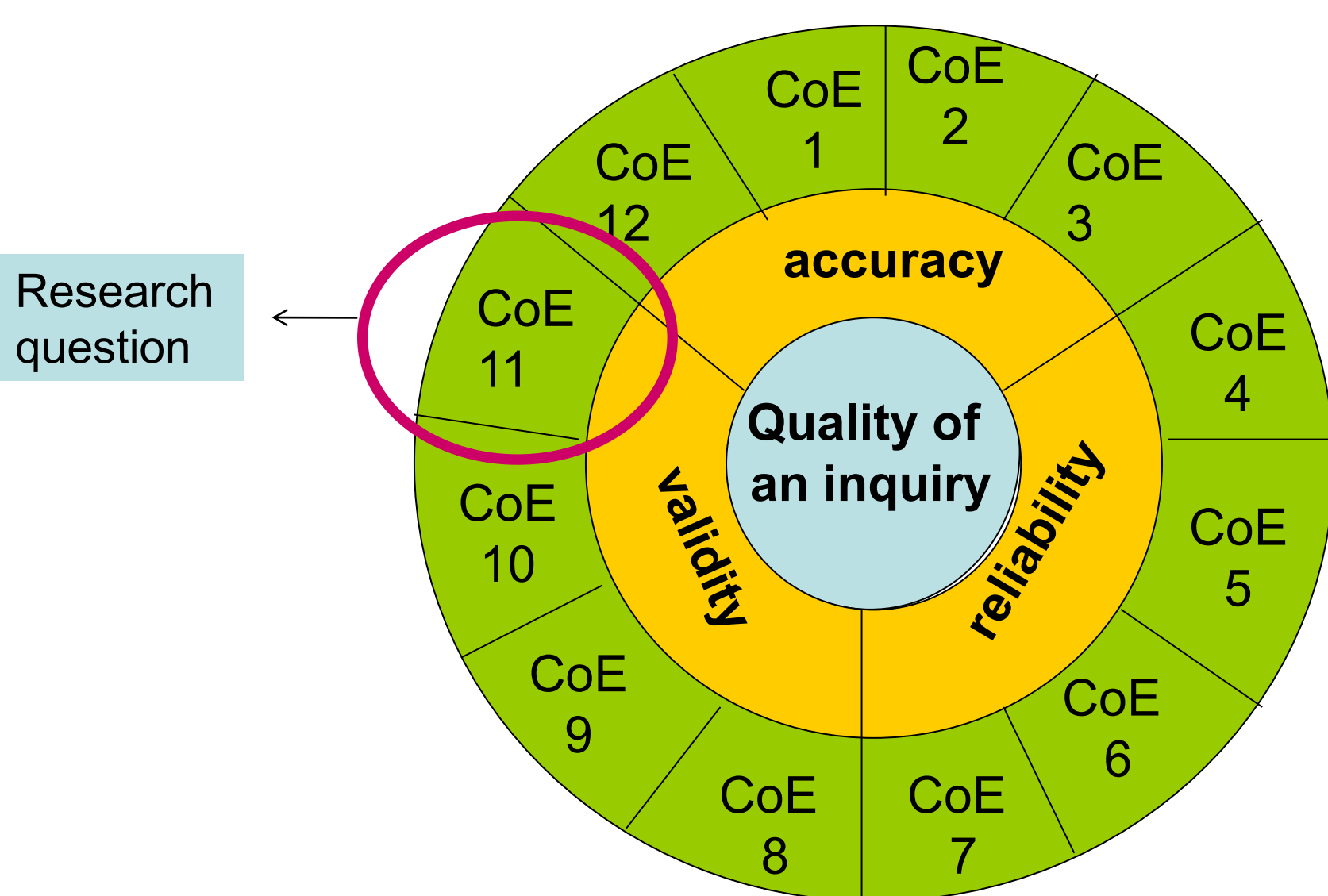
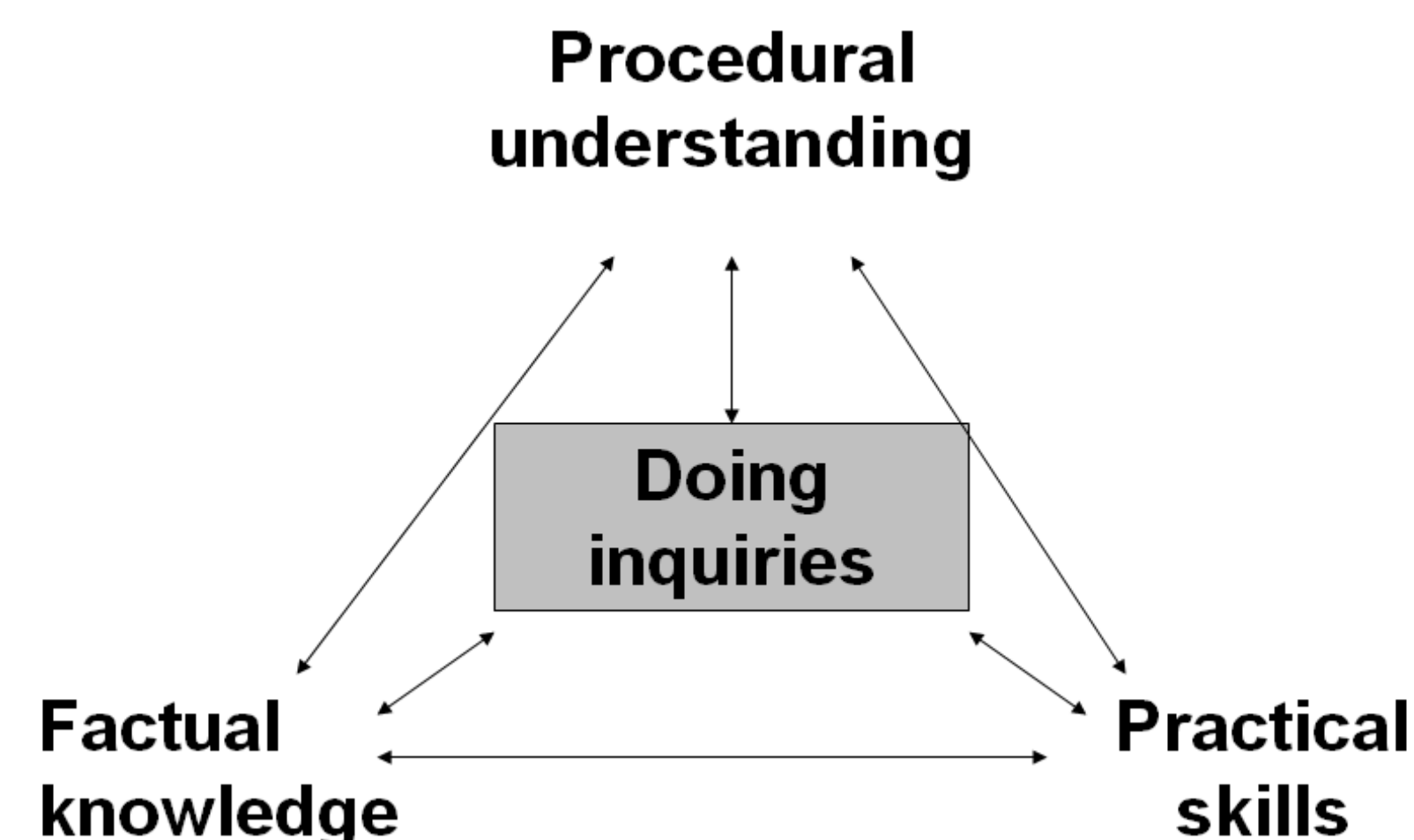
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1. Focus of the study

In secondary school students have to learn to do inquiries in physics, chemistry and biology. In the eyes of upper secondary school students the inquiries they perform seem to be quite specific for each school science subject, even if the inquiries of the different subjects require similar procedural understanding. As a result of these experienced differences students consider the processes of inquiry in different sciences as distinctive. Therefore it is necessary to learn students how to transfer procedural understanding from one specific research context to another. To learn more about this coherence students should gain insight in the differences and similarities in the meaning of validity, reliability and accuracy in the different science disciplines. Furthermore, it is important to explicate the coherence across the contexts of research in the different sciences in ensuring the quality of an inquiry.



2. Theoretical framework

Recent educational research in chemistry (Van Rens, 2005) and biology (Schalk, 2006) shows that students perform better in inquiring when they use the concepts of evidence (CoE) (Gott, Duggan, Roberts, & Hussain, n.d.). These CoE help them to control the validity, reliability and accuracy of an inquiry. By using the CoE students improve their procedural understanding of doing inquiries (Gott & Duggan, 1995). Validity, reliability and accuracy have a different meaning in the different sciences (Van Oers, 1998). For example: to get reliable results in an experiment in physics, measurements have to be accurate. In biology, results are reliable when a representative sample of a population has been taken. This implicates that there is need for a method to transfer concepts from a specific research context to another. Rubrics - a formative assessment instrument - seem to be a useful tool to facilitate this for students. In rubrics the different levels of application of CoE can be described by using the five levels of response of the Structure of the Observed Learning Outcomes (SOLO) Taxonomy. This taxonomy has been developed to view the progress in learning (Biggs & Collis, 1982).

3. Research question

What are design principles for a feasible and effective teaching-learning trajectory for learning to use the concepts validity, reliability and accuracy in different research contexts of the science subjects in upper secondary school?

4. Research design & methods

Methodology

Design-based research (Van den Akker, Gravemeijer, McKenny, & Nieveen, 2006).

Identifying design principles & preparing design

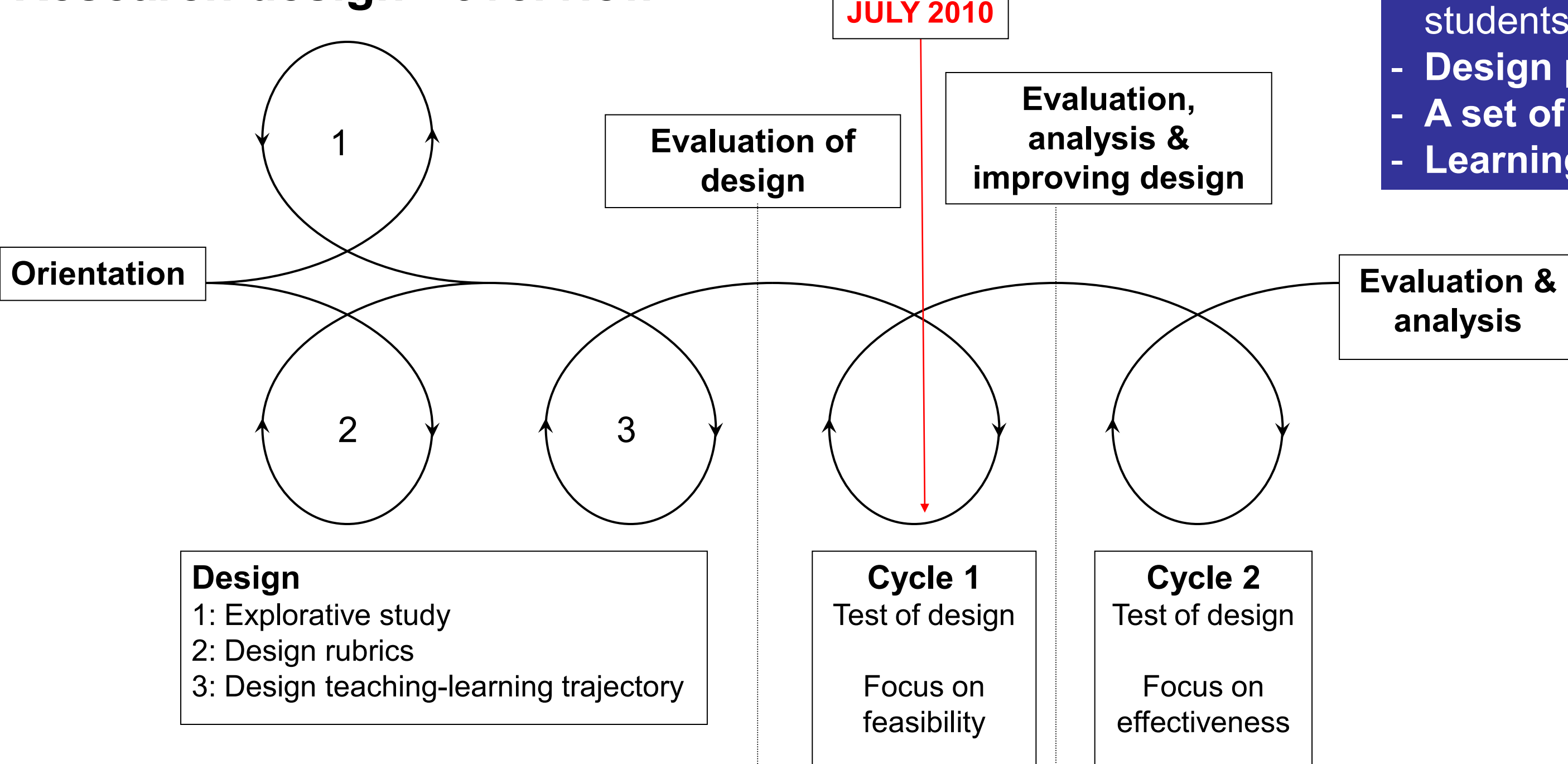
- 1) Explorative study** on the focus of students and science teachers on accuracy, reliability and validity of an inquiry.
- 2) Design of rubrics** (formative assessment instrument, see example →)
 - Content based on results explorative study.
 - Use of structure of the SOLO Taxonomy for describing different levels.
- 3) Design of teaching-learning trajectory** for learning to inquire in biology, chemistry and physics.
 - Learning materials consist of:
 - General starting unit about doing inquiries (9 lessons)
 - Inquiry unit in biology (6 lessons & collection of data in the zoo)
 - Inquiry unit in physics (6 lessons)
 - Inquiry unit in chemistry (6 lessons)
 - Same rubrics are used in each unit → promotion of coherence between science subjects.

Test, evaluation & analysis of design

Cycle 1: focus on feasibility of teaching-learning trajectory

Cycle 2: focus on effectiveness of teaching-learning trajectory

Research design - overview



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Example of a rubric: Research question

Based on levels of the SOLO Taxonomy (Biggs & Collis, 1982) & explorative study
Translated literally from Dutch rubric.

Research question		
Mark the description that fits your research question the best.	Description	Example of research question
Prestructural	The research question is formulated in general terms. The formulation is mostly based on knowledge from your daily life.	<i>What is liquor?</i>
Unistructural	In the research question you mention one of the variables of the inquiry or you mention more than one independent and/or dependent variable. You make use of professional terms to formulate the research question.	<i>What happens to your blood rate when you're standing upside down?</i>
Multistructural	In the research question you mention the independent and dependent variable of the inquiry. The formulation shows that you have basic knowledge of the research issue.	<i>Which washing-up liquid cleans the best: one with zeolite or one with phosphates?</i>
Relational	In the research question you give, with the help of the relevant variables, a explicit description of the objective of the inquiry. The formulation shows that you know how this inquiry fits into the research field.	<i>What's the relation between the angle of incidence of a laser in liquid and the angle of refraction of this laser?</i>
Extended abstract	In the research question is shown that you want to use this experiment to enlarge scientific knowledge in the research field. The formulation shows that you understand how your inquiry relates to scientific claims about a similar issue.	<i>To what extent can rape oil be used to make a fuel that has the same calorific value as diesel oil?</i>

5. Output

- **Contribution to theory** about 1) learning to inquire in more coherence in different school science subjects and 2) the use of rubrics to improve the procedural understanding of students.
- **Design principles** for teaching-learning trajectory and rubrics to learn to inquire.
- **A set of rubrics** for improving procedural understanding of students.
- **Learning materials** for learning to inquire in biology, chemistry and physics.

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